

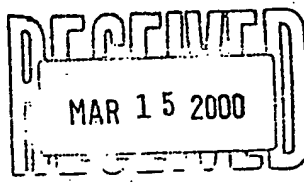
CORRECTED
VERSION*

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : C07K 14/51, 14/515, A61K 38/18		A1	(11) International Publication Number: WO 99/57146 (43) International Publication Date: 11 November 1999 (11.11.99)
(21) International Application Number: PCT/US99/04519 (22) International Filing Date: 2 March 1999 (02.03.99) (30) Priority Data: 60/083,948 1 May 1998 (01.05.98) US 09/173,989 16 October 1998 (16.10.98) US (71) Applicant: SULZER MEDICA USA INC. [US/US]; Suite 1600, 3 East Greenway Plaza, Houston, TX 77046-0391 (US). (72) Inventors: BENEDICT, James, J.; 13206 W. 33rd Place, Golden, CO 80401 (US). RANIERI, John, P.; 1406 Mohle Drive, Austin, TX 78703 (US). WHITNEY, Marsha, L.; 8912 North Lamar #258, Austin, TX 78753 (US). (74) Agents: WATKINS, Marcella, D. et al.; Conley, Rose & Tayon, P.C., P.O. Box 3267, Houston, TX 77253-3267 (US).		(81) Designated States: CA, JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i> 	
(54) Title: PROTEIN MIXTURES TO INDUCE THERAPEUTIC ANGIOGENESIS			
(57) Abstract <p>An angiogenic factor comprising a mixture of proteins derived from bone. The angiogenic protein mixture is produced by a series of steps that allow the proteins to be kept in solution. The angiogenic mixture of bone proteins is produced by a multi-step process that includes at least one ultrafiltration step, an anion exchange chromatography step, a cation exchange chromatography step and a high performance liquid chromatography (HPLC) purification step.</p>			

BEST AVAILABLE COPY

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav	TM	Turkmenistan
BF	Burkina Faso	GR	Greece		Republic of Macedonia	TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's	NZ	New Zealand		
CM	Cameroon		Republic of Korea	PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakhstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

PROTEIN MIXTURES TO INDUCE THERAPEUTIC ANGIOGENESIS

This application claims benefit from U.S. Provisional Application No. 60/083,948 filed May 1, 1998.

FIELD OF THE INVENTION

5 The present invention relates to a method for inducing the growth of blood vessels in instances where it is desirable to increase the supply of blood to a portion of a living body. More particularly, the present invention comprises a novel angiogenic factor. Still more particularly, the present invention relates to the use of mixtures of protein extracted from bone to cause therapeutic angiogenesis.

BACKGROUND OF THE INVENTION

10 There are many medical circumstances in which an increase in the supply of blood to living tissue is indicated. These include: burns and wound healing, in which the incorporation of angiogenic factors into artificial skin may facilitate the formation of blood vessels in the healing wound and reduce the risk of infection; cardiovascular disease, in
15 which repair of anginal or ischemic cardiac tissue can be effected by causing the ingrowth of new blood vessels; stroke, where increased blood supply to the brain can reduce the risk of transient ischemic attack and/or cerebral arterial deficiency; and peripheral vascular disease, in which blood flow in the extremities is diminished. In each case, it is believed that the growth of new blood vessels will increase the volume of blood circulating through the tissue
20 in question, and correspondingly increase the amount of oxygen and nutrients available to that tissue.

 Atherosclerosis is a major cause of cardiovascular disease, stroke and peripheral vascular disease. Atherosclerosis affects the blood vessels, including those of the heart. This disease may have its beginnings early in life and is first noted as a thickening of the arterial
25 walls. This thickening is an accumulation of fat, fibrin, cellular debris and calcium. The resultant narrowing of the lumen of the vessel is called stenosis. Vessel stenosis impedes and reduces blood flow. Hypertension and dysfunction of the organ or area of the body that suffers the impaired blood flow can result. As the buildup on the inner wall of a vessel thickens, the vessel wall loses the ability to expand and contract. Also, the vessel loses its
30 viability and becomes weakened and susceptible to bulging, also known as aneurysm. In the presence of hypertension or elevated blood pressure, aneurysms will frequently dissect and ultimately rupture.

Small vessels, such as the arteries that supply blood to the heart, legs, intestines and other areas of the body, are particularly susceptible to atherosclerotic narrowing. When an artery in the leg or intestine is affected, the resultant loss of blood supply to the leg or segment of the intestine may result in gangrene. Atherosclerotic narrowing of one or more of the coronary arteries limits and in some instances prevents blood flow to portions of the heart muscle. Depending upon the severity of the occlusion and its location within the coronary circulation system, pain, cardiac dysfunction or death may result.

In many instances, it is possible to correct aneurysms and stenosis of major arteries using plastic reconstruction that does not require any synthetic graft or patch materials. In other instances, such as where the disease is extensive and the vessel is no longer reliable, the blocked or weakened portion of the vessel is usually replaced with a graft. In such case, the involved vessel section is transected and removed and a synthetic patch, conduit or graft is sewn into place. These types of procedures, including coronary artery bypass grafting (CABG) and percutaneous transluminal coronary angioplasty (PTCA), are routinely performed for the purpose of alleviating ischemia.

Nevertheless, coronary artery disease alone is responsible for approximately 550,000 deaths each year in the United States. Peripheral vascular disease results in lower limb amputation in about 150,000 patients each year, with a subsequent mortality rate of 40 % within two years of amputation. Some of the difficulty in treating arterial occlusion may lie in the fact that each of these surgical procedures is associated with a certain incidence of restenosis and may not be appropriate in certain instances. This is particularly true when the patient is elderly or has undergone a previous CABG or PTCA procedure. Furthermore, in such cases, a less invasive technique is preferred.

It is believed, therefore, that stimulation of blood vessel growth into the affected region will provide the desired effect and will avoid many of the disadvantages associated with bypass surgery. While angiogenic factors in general have been the subject of much research, no angiogenic factor has yet been found to produce results that are entirely satisfactory. Examples of such growth factors are transforming growth factor beta (TGF- β), osteonectin or SPARC, platelet-derived growth factor (PDGF), basic fibroblast growth factor (bFGF) and vascular endothelial growth factor (VEGF). All of these growth factors are either synthetic, meaning they are manufactured chemically from non-living sources, or are produced by recombinant manufacturing processes. Each of these angiogenic factors comprises only a single protein and possesses only a single functionality. In addition,

many of the known angiogenic compounds are exceedingly difficult and/or expensive to manufacture.

Hence, it is desired to provide an effective angiogenic factor that is easy to manufacture from readily available materials, easily administered by the surgeon and effective at stimulating the growth of new blood vessels into the treated tissue.

BRIEF SUMMARY OF THE INVENTION

The present invention comprises an angiogenic factor that is easily manufactured from readily available materials, easily administered by the surgeon and effective at stimulating the growth of new blood vessels into the treated tissue. The angiogenic factor of the present invention comprises a group of proteins extracted from bone. It has been found that the mixtures of proteins produced by certain processes are particularly effective angiogenic agents. These angiogenic agents can be administered as part of the treatment of an existing vascular disorder, or can play a role in early intervention and prevention if administered in certain cases.

According to the present invention, a mixture of bone proteins having a surprising degree of angiogenic activity is produced by a multi-step process that includes at least one ultrafiltration step, an anion exchange chromatography step, a cation exchange chromatography step and a high performance liquid chromatography (HPLC) purification step.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more detailed description of the present invention, reference will now be made to the accompanying Figures, wherein:

Figure 1 illustrates an SDS-PAGE of one embodiment of the present angiogenic protein mixture, both in reduced and non-reduced forms;

Figure 2A-C show the results of a quail chorioallantoid membrane (CAM) angiogenesis assay of a protein mix according to the present invention;

Figures 3I-iv show the vascular growth in the CAM of Figures 2; and

Figures 4A-E are histological sections of blood vessels formed in the canine myocardium following treatment with a protein mix in accordance with the present invention.

Angiogenesis is a complex process involving several different cell types and molecular signaling events. Endothelial cells must secrete proteases to dissolve cell-cell and cell-matrix attachments, migrate and proliferate to form new vascular branches. Although single factors such as bFGF and VEGF have shown promise as angiogenic agents, a more

robust angiogenic response may be obtained through the use of an agent that comprises a mixture of proteins. This may be due in part to a synergistic effect of the combined proteins on the subject tissue. According to a preferred embodiment, an angiogenic mixture of bone proteins is produced by a multi-step process that includes an ultrafiltration step, an anion exchange chromatography step, a cation exchange chromatography step and a high performance liquid chromatography (HPLC) purification step.

While preferred processes for producing the angiogenic protein mixtures of the present invention are described in full detail in U.S. Patents 5,290,763 and 5,371,191, which are incorporated herein in their entireties, the process can be summarized as follows. In a first step, demineralized bone particles from a suitable source (such as crushed bovine bone) are subjected to protein extraction using guanidine hydrochloride. The extract solution is filtered, and subjected to a two step ultrafiltration process. In the first ultrafiltration step, an ultrafiltration membrane having a nominal molecular weight cut off (MWCO) of 100 kD is preferably employed. The retentate is discarded and the filtrate is subjected to a second ultrafiltration step using an ultrafiltration membrane preferably having a nominal MWCO of about 10 kD. The retentate is then subjected to diafiltration to substitute urea for guanidine. The protein-containing urea solution is then subjected to sequential ion exchange chromatography, first anion exchange chromatography followed by cation exchange chromatography. For the anion exchange process, a strongly cationic resin is used, preferably having quaternary amine functional groups. Typically, the eluant for the anion exchange process has a conductivity from about 10,260 micromhos (Tmhos) ($1.026 \times 10^{-2} >$ siemens (S)) to about 11,200 Tmhos ($1.120 \times 10^{-31} 2 >$ S). For the cation exchange process, a strongly anionic resin is used, preferably having sulfonic acid functional groups. The eluant for the cation exchange process typically has a conductivity from about 39,100 Tmhos ($3.91 \times 10^{-2} >$ S) to about 82,700 Tmhos ($8.27 \times 10^{-2} >$ S) or more.

In the process described above, the osteoinductively active proteins are advantageously kept in solution. According to the present invention, the osteoinductive proteins produced by the above process are then subjected to HPLC. The HPLC process preferably utilizes a column containing hydrocarbon-modified silica packing material. The osteoinductive proteins can be loaded onto the HPLC column in a solution of aqueous trifluoroacetic acid or other suitable solvent, such as heptafluorobutyric acid, hydrochloric or phosphoric acid. Preferably, a trifluoroacetic acid solution having a concentration of from

about 0.15 percent by volume, and more preferably about 0.1 percent by volume trifluoroacetic acid is used.

Osteoinductively active proteins are eluted from the HPLC column with an organic solvent/water mixture suitable for obtaining the desired proteins. A preferred eluant in the HPLC process is an acetonitrile solution. The preferred eluant typically has an acetonitrile concentration which varies, during elution, from about 30 percent by volume to about 45 percent by volume. In preferred embodiments, the acetonitrile concentration in the eluant is increased in increments of between about 0.30 percent by volume and about 0.40 percent by volume per minute until the desired highest concentration of acetonitrile is achieved. Proteins can be recovered from the HPLC process eluant by means generally known in the art. A preferred angiogenic fraction of the eluted proteins occurs when the acetonitrile concentration in the eluant is between about 33 percent by volume and about 37 percent by volume.

The purification processes described above yield novel angiogenic protein mixtures. Because they comprise mixtures of proteins, these angiogenic factors are most easily described in terms of their properties. Hence, in one embodiment of the present angiogenic factor, the factor is a mixture of a number of proteins having the sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) profile shown in FIG. 1.

Another characterization of the present invention is a mixture of proteins having a preferred amino acid composition of about 20-25 mole percent of acidic amino acids [ASP(+ ASN) and GLU(+ GLN)]; about 10-15 mole percent of hydroxy amino acids (SER and THR); about 35-45 mole percent aliphatic amino acids (ALA, GLY, PRO, MET, VAL, ILE, and LEU); about 4-10 mole percent aromatic amino acids (TYR and PHE); and about 10-20 mole percent basic amino acids (HIS, ARG and LYS). More particularly, the angiogenic protein mixture amino preferably has an amino acid composition of about 23.4 mole percent of acidic amino acids [ASP(+ ASN) and GLU(+ GLN)]; about 13.5 mole percent of hydroxy amino acids (SER and THR); about 40.0 mole percent aliphatic amino acids (ALA, GLY, PRO, MET, VAL, ILE, and LEU); about 6.8 mole percent aromatic amino acids (TYR and PHE); and about 16.6 mole percent basic amino acids (HIS, ARG and LYS). (TRP, CYS and 1/2 CYS were not measured and are not included in the calculation of mole percent.)

An alternative embodiment of the present angiogenic factor can be defined as a different fraction of the total protein stream exiting the HPLC process. More particularly, the proteins eluted when the eluant has an acetonitrile concentration of from about 37 to about

39.5 percent by volume have been found to have surprising angiogenic activity. The mixture defined in this manner contains hundreds of natural proteins. It is believed that the angiogenic activity of proteins obtained in this manner may be further enhanced by selecting smaller fractions of the eluant and quantitatively comparing the angiogenic activity of each fraction.

The bone-derived angiogenic protein (BDAP) mixture produced in accordance with the present invention is preferably administered directly to ischemic tissue in a suitable carrier. For example, in some instances, it may be desired to apply the angiogenic factor in a carrier that allows it to be absorbed quickly, while in other instances it may be desired to apply the angiogenic factor in a controlled, time-release manner. In other instances, a single dose or other variation may be preferred. In general, the preferred carrier material will vary depending on the desired clinical application or site of administration. Polylactic acid, polyglycolic acid and their copolymers, collagen, pluronic, and povidone are all examples of biocompatible materials that can be combined with BDAP mixtures to stimulate angiogenesis.

Example 1

Quail chorioallantoic membrane (CAM) was in the manner described in AA Novel Assay of Angiogenesis in the Quail Chorioallantoic Membrane: Stimulation by bFGF and Inhibition by Angiostatin According to Fractal Dimension and Grid Intersection, @ (Parsons-Wingerter P., Dwai B., Yang MC., Elliot KE., Milaninia A., Redlitz A., Clark J. and Sage E.H.. Fertilized Japanese quail eggs (*Coturnix coturnix japonica*) were opened onto Petri dishes on day 3 post-incubation (Figure 2A). After 4 days of culture, a BDAP mixture, diluted in PBS/ovalbumin prewarmed to 37°C, was distributed evenly onto the surface of the CAM. After 24 hours of incubation, the CAMs were fixed, dissected and photographed (Figure 2B) at 10x magnification to visualize the arterial vascular tree, including endstage vessels. Digital images of triplicate CAM specimens were acquired at 10x magnification in grayscale, binarized to black-and-white, and skeletonized (Figure 2C). The vessel branching pattern was analyzed and quantified by the fractal dimension.

The photographs in Figure 3 are representative digital binarized images of CAMs exposed to 10 Tg/ml dose of growth factor for 24 hours. Quantitative data corresponding to these images were acquired by analyzing the skeletonized images and determining the fractal dimension of the branched vascular pattern. Data were pooled from two separate experiments consisting of three CAMs per experiment. Exposure to BDAP resulted in 124%

greater mean angiogenic stimulation over the basal rate (defined as the change in fractal dimension in untreated controls) versus a 43% increase over basal rate for bFGF-treated CAMs. ($p < 0.006$).

It is hypothesized that this combination of factors acts synergistically to facilitate the proliferation, migration and differentiation processes essential to angiogenesis more effectively than a single factor.

Preliminary data suggest that other fractions of proteins eluted from bone are also angiogenic. An assay of a second protein mixture, BDAP-2, defined as the fraction eluting at an acetonitrile concentration of from about 37 to about 39.5 percent, membrane was performed on quail chorioallantoic membrane (CAM) using the same protocol as that described above with respect to the BDAP assay. The angiogenic response in the quail CAM assay was 86 percent greater than the basal angiogenic rate after treatment with this alternative protein mix.

Canine Myocardial Angiogenesis Pilot Study

Four adult mongrel dogs of either sex, weighing 21-26 kg, were anesthetized and a left thoracotomy performed through the fifth intercostal space. All visible epicardial collaterals connecting LAD diagonals to circumflex or right coronary arteries were ligated to minimize collateral flow to the LAD territory and an ameroid constrictor was placed on the proximal to the first diagonal branch. After completing the procedure, 0, 10 or 100 Tg BDAP was injected in a 0.1 cc volume of povidone, as polymer microspheres suspended in povidone, or in collagen gel for a total of nine injections. Each series of injections was administered in the ischemic LAD region of the left ventricle, as well as in a non-ischemic LCX-region. The chest was closed and the animal was allowed to recover.

In order to provide an index of cellular proliferation at multiple time points after the initial surgery, bromodeoxyuridine (BrdU, 25 mg/kg, Sigma, St. Louis, MO) was administered subcutaneously on post-operative days 2, 4, 6, 8, 10, 12, 14 and 21. After two or six weeks, the dogs were euthanized and the hearts explanted and cut into samples. Samples were fixed and serial sections, 4-5 microns thick, were cut and stained with Masson's trichrome stain to evaluate the general morphology of the myocardium. Sister sections were stained using standard immunohistochemical techniques with antibodies against bromodeoxyuridine (BrdU), PC10 proliferating cell nuclear antigen (PCNA), alpha smooth muscle actin (SMA) and Factor VIII using standard techniques.

Initial histological data (Figures 4A-E) indicate that 10 or 100 micrograms of BDAP suspended in 0.1 cc povidone stimulated blood vessel formation within two weeks post injection. Whereas control sections showed no significant vessel formation and the needle tract was visible, BDAP-treated sections had several newly formed blood vessels, as evidenced by Masson's trichrome staining (Figure 4A). Immunohistochemical staining demonstrated that these vessels are lined with endothelial cells (dark stain Figure 4B) and surrounded by a layer of smooth muscle cells (brown stain Figure 4C). PCNA- and BrdU-stained sections (Figures 4D-E) indicated that these vascular endothelial and smooth muscle cells are actively proliferating. Thus, based on the qualitative results of the canine study, it was concluded that BDAP stimulates formation of new differentiated blood vessels approximately 50 B 100 Tm in diameter in canine myocardium. (Note, in Figure 4A-C, 1 cm . 200 Tm; in Figure 4D-E, 1 cm . 40 Tm).

Administration of angiogenic factors in accordance with the present invention has several advantages over the alternative methods for inducing angiogenesis, such as inflammation resulting from laser injury. The growth factors of the present invention can be delivered in a minimally invasive manner to ischemic tissues either through a thoracotomy or percutaneous catheterization without the use of expensive equipment. In addition, the process for manufacturing the present angiogenic factors can be readily scaled up to a commercial production scale. A further advantage is that the proteins are kept in solution during the purification steps and exhibit little deterioration during the production process. Another advantage is that the resultant mixture of proteins can be used directly, without the mixing that may be required with proteins produced by other processes.

While the present angiogenic factor and methods for producing and administering it have been described according to a preferred embodiment, it will be understood that departures can be made from some aspects of the foregoing description without departing from the scope of the invention.

CLAIMS

What is claimed is:

1. An angiogenic factor, comprising:
a mixture of proteins derived from ground bone.
- 5 2. The angiogenic factor according to claim 1 wherein said bone-derived protein mixture has a sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) profile comprising substantially all of the protein bands shown in FIG. 1.
3. The angiogenic factor according to claim 1 wherein said bone derived-protein mixture has an amino acid composition of about 20-27 mole percent of acidic amino acids, about 10-
10 15 mole percent of hydroxy amino acids, about 35-45 mole percent aliphatic amino acids, about 4-10 mole percent aromatic amino acids, and about 10-20 mole percent basic amino acids.
4. The angiogenic factor according to claim 1 wherein said bone derived-protein mixture comprises a fraction of a total protein stream eluted from ground, demineralized, ion-
15 exchanged bone in an HPLC column.
5. A method for inducing angiogenesis, comprising:
administering a mixture of bone-derived protein to a living tissue.
6. The method according to claim 5 wherein said bone derived protein mixture has a sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) profile comprising
20 substantially all of the protein bands shown in FIG. 1.
7. The method according to claim 5 wherein said bone derived protein mixture has an amino acid composition of about 20-27 mole percent of acidic amino acids, about 10-15 mole percent of hydroxy amino acids, about 35-45 mole percent aliphatic amino acids, about 4-10 mole percent aromatic amino acids, and about 10-20 mole percent basic amino acids.
- 25 8. The method according to claim 5 wherein said bone derived-protein mixture comprises a fraction of a total protein stream eluted from ground, ion-exchanged bone in an HPLC column.
9. An angiogenic mixture of proteins that stimulates blood vessel growth when injected in soft tissue, produced by the process comprising:
30 (i) subjecting a first solution containing demineralized bone to ultrafiltration to obtain a second solution;
(ii) loading said second solution onto an anion exchange resin;

- (iii) eluting proteins from said anion exchange resin with a first eluant to obtain an anion exchanged fraction eluate;
 - (v) loading said anion exchanged fraction eluate onto a cation exchange resin;
 - (v) eluting proteins from said cation exchange resin with a second eluant to obtain a cation exchanged fraction eluate;
 - 5 (vi) loading a solution of proteins from said cation exchanged fraction eluate onto a reverse phase HPLC column; and
 - (vii) eluting proteins from said HPLC column with a third eluant.
10. The method according to claim 9 wherein step (vii) is carried out with an eluant
10 having a gradient of increasing acetonitrile concentration ranging from about 30 percent by volume to about 40 percent by volume.
11. The method according to claim 9 wherein the eluant of step (vii) comprises a trifluoroacetic acid solution having a concentration of from about 0.05 percent by volume to about 0.15 percent by volume.
- 15 12. The method according to claim 9 wherein step (vii) results in a purified angiogenic protein mixture.
13. The method according to claim 9 wherein the second solution contains proteins having a molecular weight of less than about 100 kD.

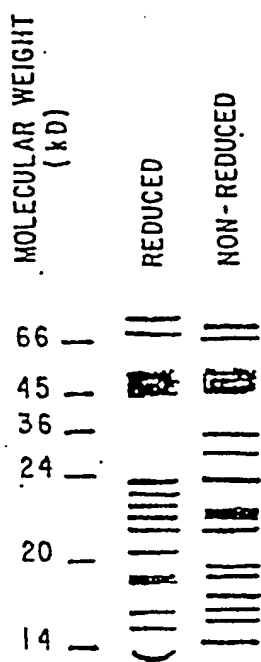
SDS - POLYACRYLAMIDE GEL OF OSTEOINDUCTIVELY ACTIVE
PROTEINS FROM HPLC

FIG. 1

Figure 2. Quail Chorioallantoic Membrane (CAM) Angiogenesis Assay

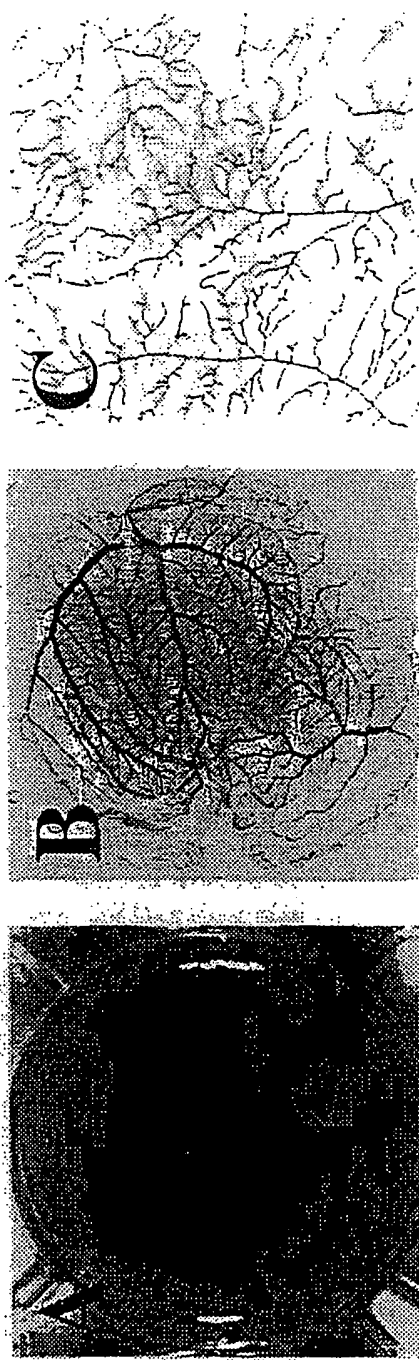


Figure 3. Black and white images of CAM vasculature after growth factor treatment

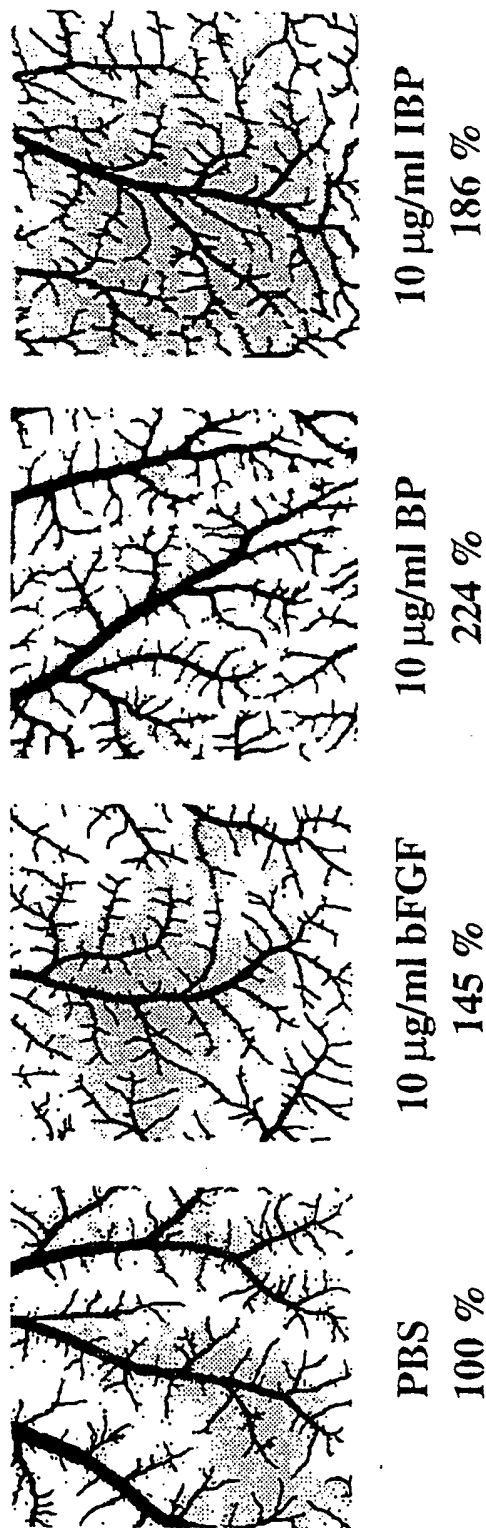


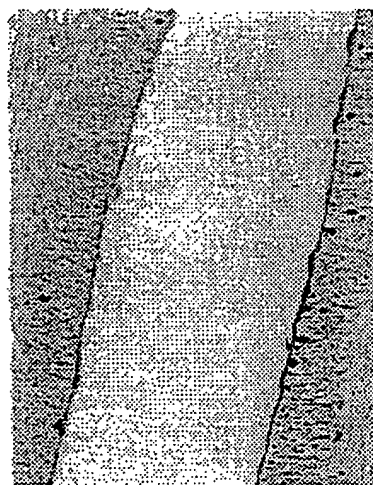
Figure 4. Histological sections of blood vessels formed in canine myocardium 2 weeks following BP injection



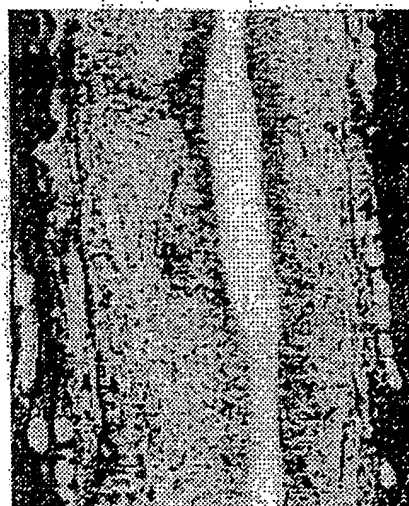
C. Smooth Muscle Actin (SMA)



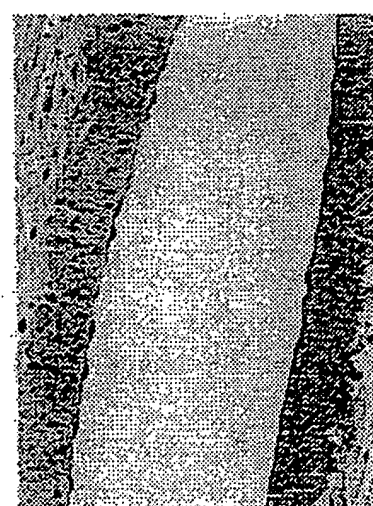
B. Factor VIII



E. BrdU



A. Trichrome stain



D. Proliferating Cell Nuclear Antigen (PCNA)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/04519

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5371191 A	06-12-1994	US 5290763 A	01-03-1994
		CA 2107481 A	23-10-1992
		EP 0584283 A	02-03-1994
		JP 6507173 T	11-08-1994
		WO 9218142 A	29-10-1992
		US 5563124 A	08-10-1996

INTERNATIONAL SEARCH REPORT

In ternational application No.

PCT/US 99/ 04519

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
Remark: Although claims 5-8 are directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims: it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/04519

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>US 5 371 191 A (POSER JAMES W ET AL) 6 December 1994 (1994-12-06) cited in the application the whole document, especially table IV, col.14</p> <p>-----</p>	1-13

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 99/04519

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 C07K14/51 C07K14/515 A61K38/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 A61K C07K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>LEVINE J P ET AL: "Bone morphogenetic protein promotes vascularization and osteoinduction in preformed hydroxyapatite in the rabbit." ANNALS OF PLASTIC SURGERY, (1997 AUG) 39 (2) 158-68. , XP002115397 abstract page 159, column 2, line 11 -page 160, column 1, line 19 page 164, column 1, line 8 - line 10 page 165, column 1, line 1 -page 166, column 1, line 22 page 167, column 2, line 9 - line 14 --- -/--</p>	1-13

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

20 September 1999

Date of mailing of the international search report

05/10/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040. Tx. 31 651 epo nl.

Authorized officer

THIS PAGE BLANK (USPTO)